What Is Claimed Is:

- 1. A broadband Sagnac Raman amplifier comprising:
- a first reflector;
- a second reflector comprising a Sagnac loop mirror fabricated from a distributed gain medium and a coupling means connected to two ends of said Sagnac loop mirror, said first reflector and said second reflector forming an optical resonator therebetween;

an input port for inputting an optical signal to said distributed gain medium;

a pumping means for generating a pumping light to pump said distributed gain medium; and

an output port for outputting said optical signal from said distributed gain medium.

- 2. The broadband Sagnac Raman amplifier according to claim 1, wherein said pumping means is a broadband pump comprising:
 - a pump laser having an output port; and
 - a bandwidth adding mirror connected to said output port to generate a broadened pump spectrum.
- 3. The broadband Sagnac Raman amplifier according to claim 2, wherein said bandwidth adding mirror comprises a Sagnac loop mirror.
 - 4. The broadband Sagnac Raman amplifier according to claim 3, wherein said bandwidth adding mirror further comprises a coupler with an unequal ratio.
 - 5. The broadband Sagnac Raman amplifier according to claim 4, wherein said coupler has a ratio of f:(1-f), and 0-s-f-s-1.
- 6. The broadband Sagnac Raman amplifier according to claim 3, wherein said bandwidth adding mirror further

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comprises a polarization controller located within said Sagnac loop mirror.

- 7. The broadband Sagnac Raman amplifier according to claim 3, wherein said bandwidth adding mirror further comprises a phase modulator asymmetrically located within said Sagnac loop mirror.
- 8. The broadband Sagnac amplifier according to claim 3, wherein said bandwidth adding mirror further comprises an amplitude modulator asymmetrically located within said Sagnac loop mirror.
 - 9. The broadband Sagnac Raman amplifier according to claim 2, wherein said pump laser is a cladding pumped fiber laser.
- 10. The broadband Sagnac Raman amplifier according to claim 9, wherein said cladding pumped fiber laser is driven by a modulated pump drive.
- 11. The broadband Sagnac Raman amplifier according to claim 9, wherein a mechanical modulation is applied to said cladding pumped fiber.
- 12. The broadband Sagnac Raman amplifier according to claim 1, wherein said distributed gain medium comprises polarization maintaining fibers cross-spliced at a joint in said Sagnac loop mirror and said coupling means is polarization maintaining, and said polarization maintaining fibers interchange polarization axes at the cross-splicing joint.

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^{13.} The broadband Sagnac Raman amplifier according to claim 12, wherein said coupling means is a coupler having a ratio of 50:50.

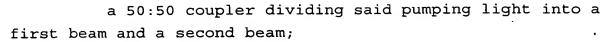
- 14. The broadband Sagnac Raman amplifier according to claim 12, wherein said coupling means is a bulk 50:50 beam splitter.
- 15. The broadband Sagnac Raman amplifier according 5 to claim 12, wherein said pumping means is a broadband pump comprising a pump laser and a bandwidth adding mirror attached thereto.
- 16. The broadband Sagnac Raman amplifier according to claim 12, wherein said input and output ports are polarization maintaining WDMs.
 - 17. The broadband Sagnac Raman amplifier according to claim 1, wherein said pumping means comprises:
 - a pump laser generating a linearly polarized pumping light; and
- a polarization maintaining fiber,
 said pumping light being launched at a 45 degree
 angle into said polarization maintaining fiber to produce a
 beam having two polarization directions.
- 18. The broadband Sagnac Raman amplifier according to claim 1, wherein said pumping means comprises:
 - a pump laser generating a linearly polarized
 pumping light;
 - a polarization maintaining fiber; and
- a quarter wavelength plate located between said pumping means and said polarization maintaining fiber such that said polarization maintaining fiber produces a beam having two polarization directions.
 - 19. The broadband Sagnac Raman amplifier according

to claim 1, wherein said pumping means comprises:

a pump laser generating a linearly polarized

30 pumping light;

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a retarder located in the path of said first beam to change the polarization direction of said first beam; and a polarization beam splitter for combining said

- 5 first beam and said second beam to produce a beam having two polarization directions.
 - 20. The broadband Sagnac Raman amplifier according to claim 19, wherein said retarder is a half-wave plate.
- 10 21. The broadband Sagnac Raman amplifier according to claim 19, wherein said retarder is a quarter-wave plate.
 - 22. The broadband Sagnac Raman amplifier according to claim 1, wherein said pumping means comprises:
 - a pump laser generating a pumping light;
- a cladding-pumped fiber having two ends, one end being pumped by said pumping light;
 - a polarization maintaining fiber spliced at a 45 degree angle to the other end of said cladding-pumped fiber to output from said polarization maintaining fiber a beam having two polarization directions.

- 23. A broadband Sagnac Raman cascade laser comprising:
 - a first reflector;
- a second reflector comprising a Sagnac loop mirror fabricated from a distributed gain medium and a coupling
- means connected to two ends of said Sagnac loop mirror, said first reflector and said second reflector forming an optical resonator therebetween;
 - a pumping means for generating a pumping light to pump said distributed gain medium; and
- an output port for outputting an optical signal 30 from said distributed gain medium.



- The broadband Sagnac Raman cascade laser according to claim 23, wherein said pumping means is a broadband pump comprising:
- a pump laser having an output port; and a bandwidth adding mirror connected to said output 5 port to generate a broadened pump spectrum.
 - The broadband Sagnac Raman cascade laser according to claim 24, wherein said bandwidth adding mirror comprises a Sagnac loop mirror.
- 10 The broadband Sagnac Raman cascade laser 26. according to claim 25, wherein said bandwidth adding mirror further comprises a coupler with an unequal ratio.
- The broadband Sagnac Raman cascade laser 27. according to claim 26, wherein said coupler has a ratio of $15 f: (1-f), and 0 \le f \le 1.$
 - The broadband Sagnac Raman cascade laser according to claim 25, wherein said bandwidth adding mirror further comprises a polarization controller located within said Sagnac loop mirror. 2.3
 - The broadband Sagnac Raman cascade laser according to claim 25, wherein said bandwidth adding mirror further comprises a phase modulator asymmetrically located within said Sagnac loop mirror.
- 30. The broadband Sagnac Raman cascade laser according to claim 25, wherein said bandwidth adding mirror further comprises an amplitude modulator asymmetrically located_within_said_Sagnac_loop_mirror._
- The broadband Sagnac Raman cascade laser 30 according to claim 24, wherein said pump laser is a cladding pumped fiber laser.

- 32. The broadband Sagnac Raman cascade laser according to claim 31, wherein said cladding pumped fiber laser is driven by a modulated pump drive.
- 33. The broadband Sagnac Raman cascade laser
 5 according to claim 31, wherein a mechanical modulation is applied to said cladding pumped fiber.
- 34. The broadband Sagnac Raman cascade laser according to claim 23, wherein said distributed gain medium comprises polarization maintaining fibers cross-spliced at a joint in said Sagnac loop mirror and said coupling means is polarization maintaining, and said polarization maintaining fibers interchange polarization axes at the cross-splicing joint.
- 35. The broadband Sagnac Raman cascade laser according to claim 34, wherein said coupling means is a coupler having a ratio of 50:50.
 - 36. The broadband Sagnac Raman cascade laser according to claim 34, wherein said coupling means is a bulk 50:50 beam splitter.
 - 37. The broadband Sagnac Raman cascade laser according to claim 34, wherein said pumping means is a broadband pump comprising a pump laser and a bandwidth adding mirror attached thereto.
- 38. The broadband Sagnac Raman cascade laser according to claim 34, wherein said output port is a polarization maintaining WDM.
 - 39. A broadband pump, comprising:
 - a pump laser having an output port; and
- a bandwidth adding mirror connected to said output port to generate a broadened pump spectrum.

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- 40. The broadband pump according to claim 39, wherein said bandwidth adding mirror comprises a Sagnac loop mirror.
- 41. The broadband pump according to claim 40, 5 wherein said bandwidth adding mirror further comprises a coupler with an unequal ratio.
 - 42. The broadband pump according to claim 41, wherein said coupler has a ratio of f:(1-f), and $0 \le f \le 1$.
- 43. The broadband pump according to claim 40, wherein said bandwidth adding mirror further comprises a polarization controller located within said Sagnac loop mirror.
- 44. The broadband pump according to claim 40,

 15 wherein said bandwidth adding mirror further comprises a

 phase modulator asymmetrically located within said Sagnac
 loop mirror.
- 45. The broadband pump according to claim 40, wherein said bandwidth adding mirror further comprises an amplitude modulator asymmetrically located within said Sagnac loop mirror.
 - 46. The broadband pump according to claim 39, wherein said pump laser is a cladding pumped fiber laser.
- 47. The broadband pump according to claim 46, wherein said cladding pumped fiber laser is driven by a modulated pump drive.

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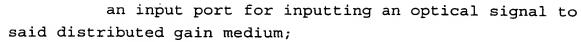
^{48.} The broadband pump according to claim 46, wherein a mechanical modulation is applied to said cladding pumped fiber.

- 49. A broadband Sagnac Raman cascade laser comprising:
 - a first reflector;
- a second reflector comprising a Sagnac loop mirror fabricated from a distributed gain medium and a coupler
- 5 connected to two ends of said Sagnac loop mirror, said first reflector and said second reflector forming an optical resonator therebetween;
- a cladding-pumped fiber located in said optical resonator;
- a pumping means for generating a pumping light to pump said cladding-pumped fiber; and

an output port for outputting an optical signal from said distributed gain medium.

- 50. The broadband Sagnac Raman cascade laser according to claim 49, wherein said coupler has a ratio of 15 50:50.
 - 51. The broadband Sagnac Raman cascade laser according to claim 49, wherein said pumping means is a diode pump array.
- 20 52. The broadband Sagnac Raman cascade laser according to claim 49, further comprising a polarization controller.
 - 53. The broadband Sagnac Raman cascade laser according to claim 49, wherein said output port is a WDM.
 - 54. A broadband Sagnac Raman amplifier comprising: a first reflector;
 - a second reflector comprising a Sagnac loop mirror

fabricated from a distributed gain medium and a coupler connected to two ends of said Sagnac loop mirror, said first reflector and said second reflector forming an optical resonator therebetween;



- a cladding-pumped fiber located in said optical resonator;
- a pumping means for generating a pumping light to 5 pump said cladding-pumped fiber; and
 - an output port for outputting said optical signal from said distributed gain medium.
- 55. The broadband Sagnac Raman amplifier according to claim 54, wherein said coupler has a ratio of 50:50.
 - 56. The broadband Sagnac Raman amplifier according to claim 54, wherein said pumping means is a diode pump array.
- 57. The broadband Sagnac Raman amplifier according to claim 54, further comprising a polarization controller.
 - 58. The broadband Sagnac Raman amplifier according to claim 54, wherein said input port and output port are WDMs.
- 59. The broadband Sagnac Raman amplifier according to claim 54, further comprising a gain flattening element connected to said output port.
 - 60. A broadband Sagnac Raman amplifier comprising: a first reflector;
- a second reflector comprising a Sagnac loop mirror fabricated from a distributed gain medium and a coupler connected to two ends of said Sagnac loop mirror, said first reflector and said second reflector forming an optical

resonator therebetween;

an input port for inputting an optical signal to 30 said distributed gain medium;

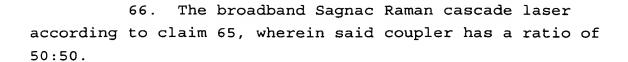
a pumping means for generating a pumping light to pump said distributed gain medium, said pumping means being connected to one of said two ends of said Sagnac loop mirror; and

an output port for outputting said optical signal ⁵ from said distributed gain medium.

- 61. The broadband Sagnac Raman amplifier according to claim 60, wherein said coupler has a ratio of 50:50.
- 62. The broadband Sagnac Raman amplifier according to claim 60, wherein said pumping means is a pump laser.
 - 63. The broadband Sagnac Raman amplifier according to claim 60, further comprising a polarization controller.
- 64. The broadband Sagnac Raman amplifier according to claim 60, wherein said input port and output port are WDMs.
 - 65. A broadband Sagnac Raman cascade laser comprising:
 - a first reflector;
- a second reflector comprising a Sagnac loop mirror fabricated from a distributed gain medium and a coupler connected to two ends of said Sagnac loop mirror, said first reflector and said second reflector forming an optical resonator therebetween;
- a pumping means for generating a pumping light to

 25 pump said distributed gain medium, said pumping means being
 connected to one of said two ends of said Sagnac loop mirror;
 and

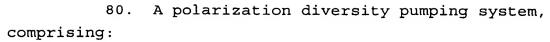
_____an_output_port_for_outputting_an_optical_signal_ from said distributed gain medium.



- 67. The broadband Sagnac Raman cascade laser
 5 according to claim 65, wherein said pumping means is a pump laser.
 - 68. The broadband Sagnac Raman cascade laser according to claim 65, further comprising a polarization controller.

- 69. The broadband Sagnac Raman cascade laser according to claim 65, wherein said output port is a WDM.
 - 70. A broadband Sagnac Raman amplifier comprising: a first reflector:
- a second reflector comprising a Sagnac loop mirror fabricated from a polarization maintaining fiber and a coupler connected to two ends of said Sagnac loop mirror, said first reflector and said second reflector forming an optical resonator therebetween;
- a Raman gain fiber located in said optical resonator;
 - an input port for inputting an optical signal to said distributed gain medium;
 - a pumping means for generating a pumping light to pump said Raman gain fiber; and
- an output port for outputting said optical signal from said distributed gain medium.
 - 71. The broadband Sagnac Raman amplifier according to_claim_70,_wherein_said_coupler_has_a_ratio_of_50:50.____
- 72. The broadband Sagnac Raman amplifier according 30 to claim 70, wherein said Sagnac loop mirror comprises a dispersion-shifted polarization maintaining fiber.

- 73. The broadband Sagnac Raman amplifier according to claim 70, wherein said pumping means is a broadband pump comprising
- a pump laser having an output port; and
 a bandwidth adding mirror attached to said output
 5 port.
 - 74. The broadband Sagnac Raman amplifier according to claim 70, wherein said input port and output port are polarization maintaining WDMs.
- 75. The broadband Sagnac Raman amplifier according to claim 70, wherein said first reflector comprises a Sagnac loop mirror fabricated from a polarization maintaining fiber and a coupler connected to two ends of said Sagnac loop mirror.
- 76. The broadband Sagnac Raman amplifier according to claim 75, wherein said coupler of said first reflector has a ratio of 50:50.
- 77. The broadband Sagnac Raman amplifier according to claim 75, wherein said Sagnac loop mirror of said first reflector comprises a dispersion-shifted polarization maintaining fiber.
 - 78. A polarization diversity pumping system, comprising:
- a pumping means generating a linearly polarized pumping light; and
 - a polarization maintaining fiber,
 - said pumping light being launched at a 45 degree angle—into said polarization—maintaining—fiber—to—produce—abeam having two polarization directions.
- 79. The polarization diversity pumping system according to claim 78, wherein said pumping means is a laser.



a pumping means generating a linearly polarized
pumping light;

- a polarization maintaining fiber; and
 a quarter wavelength plate located between said
 pumping means and said polarization maintaining fiber such
 that said polarization maintaining fiber produces a beam
 having two polarization directions.
- \$1.\$ The polarization diversity pumping system 10 according to claim 80, wherein said pump means is a laser.
 - 82. A polarization diversity pumping system, comprising:

a pumping means generating a linearly polarized pumping light;

a 50:50 coupler dividing said pumping light into a first and second beams;

a retarder located in the path of said first beam to change the polarization direction of said first beam; and

a polarization beam splitter for combining said first and second beams to produce a beam having two polarization directions.

- 83. The polarization diversity pumping system according to claim 82, wherein said pump means is a laser.
- 25 according to claim 82, wherein said retarder is a half-wave plate.
 - 85. The polarization diversity pumping system—according to claim 82, wherein said retarder is a quarter-wave plate.





- 86. A polarization diversity pumping system, comprising:
 - a pumping means generating a pumping light;
- a cladding-pumped fiber having two ends, one end being pumped by said pumping light;
- a polarization maintaining fiber spliced at a 45 degree angle to the other end of said cladding-pumped fiber to output from said polarization maintaining fiber a beam having two polarization directions.
- 87. A two-wavelength broadband Sagnac Raman 10 amplifier, comprising:
 - a separating means for separating an optical signal to be amplified into a first and second beams, said first beam having a different wavelength from said second beam;
 - a first broadband Sagnac Raman amplifier comprising a first reflector;
- a second reflector comprising a Sagnac loop mirror fabricated from a distributed gain medium and a coupling means connected to two ends of said Sagnac loop mirror, said first reflector and said second reflector forming an optical resonator therebetween;
- an input port for inputting said first beam to $^{\mathbf{20}}$ said distributed gain medium; and
 - an output port for outputting said first beam from said distributed gain medium;
 - a second broadband Sagnac Raman amplifier comprising
 - a first reflector;
- a second reflector comprising a Sagnac loop mirror fabricated from a distributed gain medium and a coupling means connected to two ends of said Sagnac loop mirror, said first reflector and said second reflector

 forming—an—optical—resonator—therebetween;
- an input port for inputting said second beam $^{\bf 30}$ to said distributed gain medium; and

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an output port for outputting said second beam from said distributed gain medium;

a pumping means for generating a pumping light to pump said distributed gain mediums of said first and second broadband Sagnac Raman amplifiers; and

a combining means for combining said first and second beams.

- 88. The two-wavelength broadband Sagnac Raman amplifier according to claim 87, wherein said first broadband Sagnac Raman amplifier is operated at a wavelength of approximately 1310 nm.
 - 89. The two-wavelength broadband Sagnac Raman amplifier according to claim 87, wherein said second broadband Sagnac Raman amplifiers is operated at a wavelength of approximately 1550 nm.

90. A two-wavelength broadband Sagnac Raman amplifier, comprising:

a separating means for separating an optical signal to be amplified into a first and second beams, said first beam having a different wavelength from said second beam;

a broadband Sagnac Raman amplifier comprising

a first reflector;

a second reflector comprising a Sagnac loop mirror fabricated from a distributed gain medium and a coupling means connected to two ends of said Sagnac loop mirror, said first reflector and said second reflector

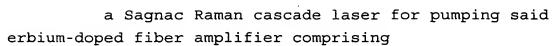
25 forming an optical resonator therebetween;

an input port for inputting said first beam to said distributed gain medium; and

an output port for outputting said first beam from said distributed gain medium;

an erbium-doped fiber amplifier having an input 30 port and an output port, said input port receiving said second beam;

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a first reflector;

a second reflector comprising a Sagnac loop mirror fabricated from a distributed gain medium and a 5 coupling means connected to two ends of said Sagnac loop mirror, said first reflector and said second reflector forming an optical resonator therebetween; and

an output port for outputting a pumping beam from said distributed gain medium, wherein said pumping beam pumping said erbium-doped fiber amplifier;

a pumping means for generating a pumping light to pump said distributed gain media of said broadband Sagnac Raman amplifier and said Sagnac Raman cascade laser; and

a combining means for combining said first beam and said second beam from said distributed gain medium of said broadband Sagnac Raman amplifier and said erbium-doped fiber amplifier respectively.

91. The two-wavelength broadband Sagnac Raman amplifier according to claim 90, wherein said broadband Sagnac Raman amplifier is operated at a wavelength of approximately 1310 nm.

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92. The two-wavelength broadband Sagnac Raman amplifier according to claim 90, wherein said Sagnac Raman cascade laser produces a pumping beam having a wavelength of approximately 1480 nm.

93. A two-wavelength broadband Sagnac Raman amplifier, comprising:

a separating means for separating an optical signal to be amplified into a first beam and a second beam, said first beam having a different wavelength from said second beam;

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a broadband Sagnac Raman amplifier comprising a first reflector:



a second reflector comprising a Sagnac loop mirror fabricated from a distributed gain medium and a coupling means connected to two ends of said Sagnac loop mirror, said first reflector and said second reflector forming an optical resonator therebetween;

an input port for inputting said first beam to said distributed gain medium; and

a pumping means for generating a pumping light to pump said distributed gain medium;

an output port for outputting said first beam from said distributed gain medium;

an erbium-doped fiber amplifier having an input port and an output port, said input port receiving said second beam; and

a combining means for combining said first beam and said second beam from said distributed gain medium of said broadband Sagnac Raman amplifier and said erbium-doped fiber amplifier respectively.

94. The two-wavelength broadband Sagnac Raman amplifier according to claim 93, wherein said broadband Sagnac Raman amplifier is operated at a wavelength of approximately 1310 nm.

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